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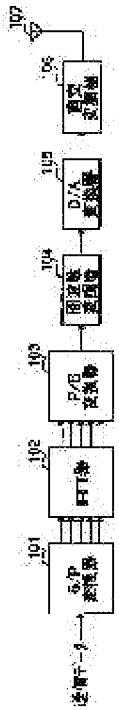
(54) OFDM TRANSMITTER AND OFDM RECEIVER



(57)Abstract:
PROBLEM TO BE SOLVED: To prevent increase in bit error rate and deterioration of transmission efficiency due to DC offset and carrier leakage.
SOLUTION: Transmission data is converted into a parallel signal by means of a S/P converter 101, and is subjected to IFFT by means of an IFFT device 102, and then is converted into a serial signal by means of a P/S converter 103. The OFDM signal is frequency-modulated by a frequency modulator 104 so that, out of the subcarriers which constitute the OFDM signal, those assigned with transmission signals may be disposed in other region than a DC component generation region.

CLAIMS

[Claim(s)]
[Claim 1]An OFDM sending set comprising:
A creating means which generates an OFDM signal by carrying out Frequency-Division-Multiplexing processing of the sending signal.
A frequency modulation means which carries out the frequency modulation of the OFDM signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal may be arranged in addition to a dc-component generating region.

[Claim 2]The OFDM sending set according to claim 1, wherein a frequency modulation means arranges any one of the subcarriers contained in a guard band of an OFDM signal to a dc-component generating region.
[Claim 3]The OFDM sending set according to claim 1 or 2, wherein a frequency modulation means carries out the frequency modulation of the OFDM signal before inputting it into analog circuitry.
[Claim 4]An OFDM receiving set comprising:
A reception means in which two or more subcarriers receive an OFDM signal by which multiplex was carried out from a communications partner.
A frequency modulation means which carries out the frequency modulation of the OFDM signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal may be arranged in addition to a dc-component generating region.

[Claim 5]An OFDM receiving set comprising:
A reception means which receives a signal transmitted from the OFDM sending set according to any one of claims 1 to 3.
A frequency modulation means which carries out the frequency modulation of said input signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute an input signal which said reception means received may be arranged in addition to a dc-component generating region.

[Claim 6]An OFDM transmission method by which it is carrying-out [so that a subcarrier to which a sending signal was assigned among subcarriers which generate an OFDM signal and constitute said OFDM signal by carrying out Frequency-Division-Multiplexing processing of the sending signal may be arranged in addition to a dc-component generating region]-frequency modulation of OFDM signal characterized.
[Claim 7]In the transmitting side, an OFDM signal is generated by carrying out Frequency-Division-Multiplexing processing of the sending signal, Carry out the frequency modulation of the OFDM signal, and wireless transmission is carried out so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal may be arranged in addition to a dc-component generating region, A wireless communication method carrying out the frequency modulation of said input signal so that a subcarrier to which a sending signal was assigned among

subcarriers which receive a signal transmitted from the transmitting side and constitute an input signal from a receiver may be arranged in addition to a dc-component generating region.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the OFDM communication device using an OFDM (Orthogonal Frequency Division Multiplexing) method especially about the communication apparatus used for a digital mobile communications system.
[0002]
[Description of the Prior Art]In performing radio with high access speed, in connection with a symbol period becoming short, the influence of a multipath delay wave becomes large, and input-signal quality deteriorates. It is effective to perform multi-carrier abnormal conditions to degradation of the input-signal quality by this multipath delay wave. The OFDM modulation method which carries out package abnormal conditions and carries out multiplex [of the subcarrier which is in two or more orthogonality relation using an IFFT (inverse discrete Fourier transform: InverseFast Fourier Transform) circuit in multi-carrier abnormal conditions] is typical.
[0003]In an OFDM modulation method, since it is superimposed on the DC offset generated in the subcarrier arranged at DC in analog circuitry, such as a D/A converter of the transmitting side, there is a problem that the bit error rate of a transmission signal deteriorates. In analog circuitry, such as an A/D converter in a receiver, this problem is produced similarly. The carrier leak which leaks to space etc. occurs, and when distortion arises in the subcarrier which the subcarrier which leaked to this space was inputted into the quadrature modulation machine, and has been arranged at DC, the problem that the bit error rate of a transmission signal deteriorates also has a subcarrier of the high frequency which carries out multiplication to a baseband signal. As a definition of term, the 0-Hz position of the baseband signal in an OFDM modulation method is called DC.
[0004]To these problems, the "multi-carrier modulator" is proposed, for example by JP,11-205176,A. A device given in above-mentioned JP,11-205176,A avoids the influence of the DC offset in analog circuitry, and a carrier leak by not arranging a subcarrier to DC.
[0005]
[Problem(s) to be Solved by the Invention]In the conventional OFDM modulation method, since DC is located in the center (0 Hz) of the frequency band of a baseband signal, degradation of the quality by band limit is fewest ingredients, and its transmission quality is the best. However, in the OFDM modulation method which does not arrange a subcarrier to the conventional DC, since DC is not used for transmission of a signal, there is a problem that the transmission efficiency of a signal falls.
[0006]This invention is made in view of this point, and is a thing.
It is providing the OFDM sending set and OFDM receiving set which prevent degradation of the bit error rate by the purpose and a carrier leak, and degradation of the transmission efficiency of a signal.

[0007]
[Means for Solving the Problem]A creating means which generates an OFDM signal when an OFDM sending set of this invention carries out Frequency-Division-Multiplexing processing of the sending signal, Composition possessing a frequency modulation means which carries out the frequency modulation of the OFDM signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal may be arranged in addition to a dc-component generating region is taken.
[0008]Since a subcarrier to which the frequency modulation of the OFDM signal was carried out and to which a signal was assigned has been arranged in addition to a dc-component generating region according to this composition, a subcarrier to which a signal was assigned is not distorted. Therefore, degradation of a bit error rate by DC offset and a carrier leak can be prevented.
[0009]An OFDM sending set of this invention takes composition to which a frequency modulation means arranges any one of the subcarriers contained in a guard band of an OFDM signal to a dc-component generating region in the above-mentioned OFDM sending set.
[0010]Since according to this composition a subcarrier to which frequency modulation was carried out and to which a signal was assigned has been arranged in addition to a dc-component generating region before inputting an OFDM signal into analog circuitry, A subcarrier to which a signal was assigned depending on DC offset and a carrier leak which are generated in analog circuitry is not distorted. Therefore, degradation of a bit error rate by DC offset and a carrier leak can be prevented.
[0011]In the above-mentioned OFDM sending set, an OFDM sending set of this invention takes composition which carries out the frequency modulation of the OFDM signal, before inputting a frequency modulation means into analog circuitry.
[0012]Since according to this composition frequency modulation was carried out so that a subcarrier contained in a guard band might be arranged to a dc-component generating region, a sampling number in the case of a recovery can be stopped few.
[0013]A reception means in which, as for an OFDM receiving set of this invention, two or more subcarriers receive an OFDM signal by which multiplex was carried out from a communications partner, Composition possessing a frequency modulation means which carries out the frequency modulation of the OFDM signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal may be arranged in addition to a dc-component generating region is taken.
[0014]Since a subcarrier to which the frequency modulation of the OFDM signal was carried out and to which a signal was assigned has been arranged in addition to a dc-component generating region according to this composition, a subcarrier to which a signal was assigned is not distorted. Therefore, degradation of a bit error rate by DC offset by the side of resin can be prevented.
[0015]A reception means which receives a signal with which an OFDM receiving set of this invention was transmitted from the above-mentioned OFDM sending set, Composition possessing a frequency modulation means which carries out the frequency modulation of said input signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute an input signal which said reception means

received may be arranged in addition to a dc-component generating region is taken.
[0016]According to this composition, while being able to prevent degradation of a bit error rate by DC offset and a carrier leak in the transmitting side, degradation of a bit error rate by DC offset in a receiver can also be prevented.
[0017]An OFDM transmission method of this invention generates an OFDM signal by carrying out Frequency-Division-Multiplexing processing of the sending signal, It was made to carry out the frequency modulation of the OFDM signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal might be arranged in addition to a dc-component generating region.
[0018]Since a subcarrier to which the frequency modulation of the OFDM signal was carried out and to which a signal was assigned has been arranged in addition to a dc-component generating region according to this method, a subcarrier to which a signal was assigned is not distorted. Therefore, degradation of a bit error rate by DC offset and a carrier leak can be prevented.
[0019]A wireless communication method of this invention generates an OFDM signal by carrying out Frequency-Division-Multiplexing processing of the sending signal in the transmitting side, Carry out the frequency modulation of the OFDM signal, and wireless transmission is carried out so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal may be arranged in addition to a dc-component generating region, A signal transmitted from the transmitting side is received, and in a receiver, it was made to carry out the frequency modulation of said input signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute an input signal might be arranged in addition to a dc-component generating region.
[0020]According to this method, while being able to prevent degradation of a bit error rate by DC offset and a carrier leak in the transmitting side, degradation of a bit error rate by DC offset in a receiver can also be prevented.
[0021]
[Embodiment of the Invention]Since the OFDM signal with which this invention person is generated by Frequency-Division-Multiplexing processing has a fixed frequency band (valid symbol zone), It notes that a sending signal is not assigned to the subcarrier arranged out of a valid symbol zone, Even if the distortion by DC offset or a carrier leak arose in the subcarrier arranged out of this valid symbol zone, a bit error rate and transmission efficiency find out not deteriorating, and came to carry out this invention.
[0022]Namely, the main point of this invention so that the subcarrier to which the sending signal was assigned may be arranged in addition to a dc-component generating region, That is, it is preventing degradation of the bit error rate by DC offset and a carrier leak by carrying out the frequency modulation of the OFDM signal so that the subcarrier to which a sending signal was not assigned may be arranged to a dc-component generating region.
[0023]By the way, in the OFDM modulation method, in order to reduce the influence of the delayed wave by a multipass, the guard band is provided in the zone which adjoins a valid symbol zone. Since a sending signal is not assigned to the subcarrier contained in this guard band, even if the frequency position which intersects perpendicularly with the signal in an effective band in a guard band is overlapped on a line spectrum, a bit error rate does not deteriorate. On the other hand, in order to perform the recovery of an

OFDM signal by sampling the signal of the certain area centering on DC, its sampling number at the time of getting over, so that the frequency modulation of the subcarrier to which the signal was assigned is carried out to a position far from DC increases. Therefore, in this invention, the sampling number in the case of a recovery can be reduced for the subcarrier to which the sending signal was assigned by the thing of a dc-component generating region immediately done for frequency modulation to an outside frequency band, and a processing burden can also be eased. This frequency modulation is realizable by carrying out frequency modulation so that the subcarrier contained in a guard band may be arranged to DC. That is, in this invention, the means which carries out the frequency modulation of the baseband signal so that the subcarrier arranged at the guard band may be arranged in a dc-component generating region is preferred.
[0024]In each following embodiment, the example which carries out the frequency modulation of the OFDM signal so that the subcarrier contained in a guard band may be arranged at DC is explained.
[0025](Embodiment 1) Embodiment 1 is an example which prevents degradation of the bit error rate by the DC offset and the carrier leak which are added in analog circuitry, such as an A/D converter of the transmitting side, and transmission efficiency.
[0026]Drawing 1 is a block diagram showing the composition of the OFDM sending set concerning the embodiment of the invention 1. Drawing 1 is an example of circuitry in the case of using five subcarriers for information transmission. In this figure, an OFDM sending set changes send data into a parallel signal with the S/P converter 101, IFFT (inverse discrete Fourier transform) processing is carried out with the IFFT machine 102, it changes into an in-series signal with the P/S converter 103, frequency modulation is carried out with the frequency modulator 104, D / A conversion is carried out with D/A converter 105, quadrature modulation is carried out with the quadrature modulation machine 106, and it transmits from the antenna 107. The frequency modulator 104 - the quadrature modulation machine 106 are explained in full detail behind. The IFFT machine 102 arranges the subcarrier which does not assign a sending signal to the zone which adjoins the subcarrier which assigns a signal, and forms a guard band while it assigns a subcarrier peculiar to the sending signal to the parallel signal outputted from the S/P converter 101.
[0027]As a definition of term, send data is changed into a parallel signal with the S/P converter 101, IFFT (inverse discrete Fourier transform) processing is carried out with the IFFT machine 102, the processing changed into an in-series signal with the P/S converter 103 is summarized, and it is called Frequency-Division-Multiplexing processing. The signal to which frequency multiplexing split application was performed is called OFDM signal.
[0028]Drawing 2 is a block diagram showing the composition of the OFDM sending set of drawing 1, and the OFDM receiving set which performs radio. In this figure, an OFDM receiving set carries out orthogonal detection of the input signal received from the antenna 201 with the orthogonal detector 202, Analog-to-digital conversion is carried out with A/D converter 203, and it changes into a parallel signal with the S/P converter 204, and FFT (Fast Fourier Transform) processing is carried out with the FFT machine 205, and it changes into an in-series signal with the P/S converter 206, it gets over with the demodulator 207, and received data are obtained.
[0029]Next, operation of the OFDM sending set constituted as mentioned above and an

OFDM receiving set is explained. Send data is changed into a parallel signal with the S/P converter 101, IFFT processing is carried out with the IFFT machine 102, and it is changed into an in-series signal with the P/S converter 103, and is outputted to the frequency modulator 104.
[0030]Here, the DC offset and the carrier leak ingredient which are added to an OFDM signal are explained. Drawing 3 is a figure showing the spectrum of an OFDM signal. Drawing 3 (a) is a spectrum of the OFDM signal inputted into the frequency modulator 104, Drawing 3 (b) is a spectrum of the OFDM signal with which DC offset was added in D/A converter 105, and the distortion (henceforth a "carrier leak ingredient") by a carrier leak was added in the quadrature modulation machine 106. In drawing 3 (a), the sending signal is assigned to the five subcarriers S1-S5, and these five subcarriers form a valid symbol zone. On the other hand, a sending signal is not assigned to the subcarriers S6 and S7, but a guard band for S6 and S7 to reduce distortion by a multipass is formed. That is, an OFDM signal comprises a guard band which adjoins a valid symbol zone and a valid symbol zone. By making 0 Hz (DC) into center frequency, 1 symbol length of a baseband signal leaves each subcarrier a reciprocal (=fs) every, and it is arranged.
[0031]Since each of DC offset and carrier leaks is generated in the 0-Hz neighborhood as a definition of term, DC offset and a carrier leak ingredient are collectively called dc component. The neighborhood of 0 Hz (DC) is called dc-component generating region in the meaning of the frequency domain which a dc component generates.
[0032]Frequency modulation is carried out in the frequency modulator 104, only 3 fs is shifted to the low frequency wave side, the signal shown in drawing 3 (a) is outputted to D/A converter 105, and D / A conversion is carried out in D/A converter 105. DC offset is added to the subcarrier arranged at DC in the case of this D / A conversion. This OFDM signal is outputted to the quadrature modulation machine 106, and the subcarrier of high frequency can multiply by it in the quadrature modulation machine 106. Distortion (carrier leak ingredient) occurs in the subcarrier arranged at DC of an OFDM signal by inputting into the quadrature modulation machine 106 the subcarrier which leaked to space etc. Thus, the subcarrier S6 arranged at 3fs is arranged at DC until it is inputted into the frequency modulator 104, when only 3 fs is shifted an OFDM signal to the low frequency wave side in the frequency modulator 104. Therefore, DC offset and a carrier leak ingredient are added to the subcarrier S6 arranged at DC, and the spectrum of an OFDM signal comes to be shown in drawing 3 (b). In this case, the subcarriers S1-S5 to which the signal is assigned are arranged in addition to the dc-component generating region.
[0033]Quadrature modulation of the OFDM signal which has a spectrum shown in this drawing 3 (b) is carried out with the quadrature modulation machine 106, and it is transmitted from the antenna 107.
[0034]In an OFDM receiving set, the input signal received from the antenna 201, Orthogonal detection is carried out with the orthogonal detector 202, analog-to-digital conversion is carried out with A/D converter 203, and it is changed into a parallel signal with the S/P converter 204, and FFT processing is carried out with the FFT machine 205, and it is changed into an in-series signal with the P/S converter 206, it gets over with the demodulator 207, and received data are obtained. In this case, since the position of S6 which lies at right angles to S1-S5 is overlapped on the dc component and the FFT machine 205 can separate it thoroughly, it is uninfluential to S1-S5.

[0035]Thus, since according to this embodiment the subcarrier to which the signal was assigned by carrying out frequency modulation has been arranged in addition to a dc-component generating region before inputting an OFDM signal into the analog circuitry of an OFDM sending set, the subcarrier to which the signal was assigned is not distorted. Therefore, degradation of the bit error rate by DC offset and a carrier leak can be prevented.
[0036]According to this embodiment, since frequency modulation was carried out so that the subcarrier contained in a guard band might be arranged to a dc-component generating region, the sampling number in the case of a recovery can be stopped few.
[0037](Embodiment 2) Embodiment 2 is an example which prevents degradation of the bit error rate by the DC offset added in the analog circuitry of a receiver, and transmission efficiency.
[0038]Drawing 4 is a block diagram showing the composition of the OFDM sending set concerning the embodiment of the invention 2. Drawing 4 is an example of circuitry in the case of using five subcarriers for information transmission. In this figure, an OFDM sending set changes send data into a parallel signal with the S/P converter 401, IFFT (inverse discrete Fourier transform) processing is carried out with the IFFT machine 402, it changes into an in-series signal with the P/S converter 403, D / A conversion is carried out with D/A converter 404, the multiplication of the subcarrier is carried out by quadrature modulation with the quadrature modulation machine 405, and it transmits from the antenna 406. The IFFT machine 402 assigns a subcarrier to the parallel signal outputted from the S/P converter 401.
[0039]As a definition of term, send data is changed into a parallel signal with the S/P converter 401, IFFT (inverse discrete Fourier transform) processing is carried out with the IFFT machine 402, the processing changed into an in-series signal with the P/S converter 403 is summarized, and it is called Frequency-Division-Multiplexing processing.
[0040]Drawing 5 is a block diagram showing the composition of the OFDM sending set of drawing 4, and the OFDM receiving set which performs radio. On this figure and in the orthogonal detector 502 an OFDM receiving set, Orthogonal detection of the input signal (OFDM signal) received from the antenna 501 is carried out, Carry out frequency modulation with the frequency modulator 503, and analog-to-digital conversion is carried out with A/D converter 504, It changes into a parallel signal with the S/P converter 505, and FFT (Fast Fourier Transform) processing is carried out with the FFT machine 506, and it changes into an in-series signal with the P/S converter 507, it gets over with the demodulator 508, and received data are obtained.
[0041]Next, operation of the OFDM sending set constituted as mentioned above and an OFDM receiving set is explained. Send data is changed into a parallel signal with the S/P converter 401, and IFFT processing is carried out with the IFFT machine 402, It is changed into an in-series signal with the P/S converter 403, D / A conversion is carried out with D/A converter 404, quadrature modulation carries out the multiplication of the subcarrier with the quadrature modulation machine 405, and it is transmitted from the antenna 406.
[0042]In an OFDM receiving set, in the orthogonal detector 502, orthogonal detection of the input signal received from the antenna 501 is carried out, and it is outputted to the frequency modulator 503.

[0043]Here, the DC offset and the carrier leak ingredient which are added to an OFDM signal are explained. Drawing 6 is a figure showing the spectrum of an OFDM signal. Drawing 6 (a) is a spectrum of the OFDM signal inputted into the frequency modulator 503, and drawing 6 (b) is a spectrum of the OFDM signal with which DC offset was added in A/D converter 504. In drawing 6 (a), the sending signal is assigned to the five subcarriers S1-S5, and these five subcarriers form a valid symbol zone. On the other hand, a sending signal is not assigned to the subcarriers S6 and S7, but a guard band for S6 and S7 to reduce distortion by a multipass is formed. That is, an OFDM signal comprises a guard band which adjoins a valid symbol zone and a valid symbol zone. By making 0 Hz (DC) into center frequency, 1 symbol length of a baseband signal leaves each subcarrier a reciprocal (=fs) every, and it is arranged.
[0044]Frequency modulation is carried out in the frequency modulator 503, only 3 fs is shifted to the low frequency wave side, the signal shown in drawing 6 (a) is outputted to A/D converter 504, and analog-to-digital conversion is carried out in A/D converter 504. DC offset is added to the subcarrier arranged at DC in the case of this analog-to-digital conversion. Thus, the subcarrier S6 arranged at 3fs is arranged at DC until it is inputted into the frequency modulator 503, when only 3 fs is shifted an OFDM signal to the low frequency wave side in the frequency modulator 503. Therefore, DC offset is added to the subcarrier S6 arranged at DC, and the spectrum of an OFDM signal comes to be shown in drawing 6 (b). In this case, the subcarriers S1-S5 to which the signal is assigned are arranged in addition to the dc-component generating region.
[0045]The OFDM signal which has a spectrum shown in this drawing 6 (b) is changed into a parallel signal with the S/P converter 505, and FFT processing is carried out with the FFT machine 506, and it is changed into an in-series signal with the P/S converter 507, it gets over with the demodulator 508, and received data are obtained.
[0046]Thus, since according to this embodiment the subcarrier to which the signal was assigned by carrying out frequency modulation has been arranged in addition to a dc-component generating region before inputting an OFDM signal into the analog circuitry of an OFDM receiving set, the subcarrier to which the signal was assigned is not distorted. Therefore, degradation of the bit error rate by DC offset and a carrier leak can be prevented.
[0047]It can use combining the OFDM sending set concerning the above-mentioned Embodiment 1, and the OFDM receiving set concerning Embodiment 2. Namely, the OFDM sending set concerning Embodiment 1 an OFDM signal, It transmits, after carrying out frequency modulation so that the subcarrier to which the signal was assigned may be arranged in addition to a dc-component generating region, After carrying out the frequency modulation of the OFDM signal received from the OFDM sending set which requires the OFDM receiving set concerning Embodiment 2 for Embodiment 1 so that the subcarrier assigned to the signal may be arranged in addition to a dc-component generating region, it inputs into analog circuitry and a recovery etc. are processed.
[0048]Thus, by using combining the OFDM sending set concerning Embodiment 1, and the OFDM receiving set concerning Embodiment 2, While being able to prevent degradation of the bit error rate by the DC offset and the carrier leak in the transmitting side, degradation of the bit error rate by the DC offset in a receiver can also be prevented.
[0049]Although the case where five subcarriers were contained in a valid symbol zone was explained, this invention is not restricted to this but it may be made to contain how

many subcarriers in a valid symbol zone in each above-mentioned embodiment according to an equipment configuration. Although similarly the case where two subcarriers were included in a guard band was explained, it may be made for how many subcarriers to be included.
[0050]
[Effect of the Invention]As explained above, according to this invention, degradation of the bit error rate by DC offset and a carrier leak and degradation of the transmission efficiency of a signal can be prevented.

TECHNICAL FIELD

[Field of the Invention]This invention relates to the OFDM communication device using an OFDM (Orthogonal Frequency Division Multiplexing) method especially about the communication apparatus used for a digital mobile communications system.

PRIOR ART

[Description of the Prior Art]In performing radio with high access speed, in connection with a symbol period becoming short, the influence of a multipath delay wave becomes large, and input-signal quality deteriorates. It is effective to perform multi-carrier abnormal conditions to degradation of the input-signal quality by this multipath delay wave. The OFDM modulation method which carries out package abnormal conditions and carries out multiplex [of the subcarrier which is in two or more orthogonality relation using an IFFT (inverse discrete Fourier transform: InverseFast Fourier Transform) circuit in multi-carrier abnormal conditions] is typical.
[0003]In an OFDM modulation method, since it is superimposed on the DC offset generated in the subcarrier arranged at DC in analog circuitry, such as a D/A converter of the transmitting side, there is a problem that the bit error rate of a transmission signal deteriorates. In analog circuitry, such as an A/D converter in a receiver, this problem is produced similarly. The carrier leak which leaks to space etc. occurs, and when distortion arises in the subcarrier which the subcarrier which leaked to this space was inputted into the quadrature modulation machine, and has been arranged at DC, the problem that the bit error rate of a transmission signal deteriorates also has a subcarrier of the high frequency which carries out multiplication to a baseband signal. As a definition of term, the 0-Hz position of the baseband signal in an OFDM modulation method is called DC.
[0004]To these problems, the "multi-carrier modulator" is proposed, for example by JP,11-205176,A. A device given in above-mentioned JP,11-205176,A avoids the influence of the DC offset in analog circuitry, and a carrier leak by not arranging a subcarrier to DC.

EFFECT OF THE INVENTION

[Effect of the Invention]As explained above, according to this invention, degradation of the bit error rate by DC offset and a carrier leak and degradation of the transmission efficiency of a signal can be prevented.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]In the conventional OFDM modulation method, since DC is located in the center (0 Hz) of the frequency band of a baseband signal, degradation of the quality by band limit is fewest ingredients, and its transmission quality is the best. However, in the OFDM modulation method which does not arrange a subcarrier to the conventional DC, since DC is not used for transmission of a signal, there is a problem that the transmission efficiency of a signal falls.
[0006]This invention is made in view of this point, and is a thing.
It is providing the OFDM sending set and OFDM receiving set which prevent degradation of the bit error rate by the purpose and a carrier leak, and degradation of the transmission efficiency of a signal.

MEANS

[Means for Solving the Problem]A creating means which generates an OFDM signal when an OFDM sending set of this invention carries out Frequency-Division-Multiplexing processing of the sending signal, Composition possessing a frequency modulation means which carries out the frequency modulation of the OFDM signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal may be arranged in addition to a dc-component generating region is taken.
[0008]Since a subcarrier to which the frequency modulation of the OFDM signal was carried out and to which a signal was assigned has been arranged in addition to a dc-component generating region according to this composition, a subcarrier to which a signal was assigned is not distorted. Therefore, degradation of a bit error rate by DC offset and a carrier leak can be prevented.
[0009]An OFDM sending set of this invention takes composition to which a frequency modulation means arranges any one of the subcarriers contained in a guard band of an OFDM signal to a dc-component generating region in the above-mentioned OFDM sending set.
[0010]Since according to this composition a subcarrier to which frequency modulation was carried out and to which a signal was assigned has been arranged in addition to a dc-component generating region before inputting an OFDM signal into analog circuitry, A subcarrier to which a signal was assigned depending on DC offset and a carrier leak which are generated in analog circuitry is not distorted. Therefore, degradation of a bit error rate by DC offset and a carrier leak can be prevented.
[0011]In the above-mentioned OFDM sending set, an OFDM sending set of this invention takes composition which carries out the frequency modulation of the OFDM signal, before inputting a frequency modulation means into analog circuitry.

[0012]Since according to this composition frequency modulation was carried out so that a subcarrier contained in a guard band might be arranged to a dc-component generating region, a sampling number in the case of a recovery can be stopped few.
[0013]A reception means in which, as for an OFDM receiving set of this invention, two or more subcarriers receive an OFDM signal by which multiplex was carried out from a communications partner, Composition possessing a frequency modulation means which carries out the frequency modulation of the OFDM signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal may be arranged in addition to a dc-component generating region is taken.
[0014]Since a subcarrier to which the frequency modulation of the OFDM signal was carried out and to which a signal was assigned has been arranged in addition to a dc-component generating region according to this composition, a subcarrier to which a signal was assigned is not distorted. Therefore, degradation of a bit error rate by DC offset by the side of resin can be prevented.
[0015]A reception means which receives a signal with which an OFDM receiving set of this invention was transmitted from the above-mentioned OFDM sending set, Composition possessing a frequency modulation means which carries out the frequency modulation of said input signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute an input signal which said reception means received may be arranged in addition to a dc-component generating region is taken.
[0016]According to this composition, while being able to prevent degradation of a bit error rate by DC offset and a carrier leak in the transmitting side, degradation of a bit error rate by DC offset in a receiver can also be prevented.
[0017]An OFDM transmission method of this invention generates an OFDM signal by carrying out Frequency-Division-Multiplexing processing of the sending signal, It was made to carry out the frequency modulation of the OFDM signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal might be arranged in addition to a dc-component generating region.
[0018]Since a subcarrier to which the frequency modulation of the OFDM signal was carried out and to which a signal was assigned has been arranged in addition to a dc-component generating region according to this method, a subcarrier to which a signal was assigned is not distorted. Therefore, degradation of a bit error rate by DC offset and a carrier leak can be prevented.
[0019]A wireless communication method of this invention generates an OFDM signal by carrying out Frequency-Division-Multiplexing processing of the sending signal in the transmitting side, Carry out the frequency modulation of the OFDM signal, and wireless transmission is carried out so that a subcarrier to which a sending signal was assigned among subcarriers which constitute said OFDM signal may be arranged in addition to a dc-component generating region, A signal transmitted from the transmitting side is received, and in a receiver, it was made to carry out the frequency modulation of said input signal so that a subcarrier to which a sending signal was assigned among subcarriers which constitute an input signal might be arranged in addition to a dc-component generating region.
[0020]According to this method, while being able to prevent degradation of a bit error rate by DC offset and a carrier leak in the transmitting side, degradation of a bit error rate by DC offset in a receiver can also be prevented.

[0021]
[Embodiment of the Invention]Since the OFDM signal with which this invention person is generated by Frequency-Division-Multiplexing processing has a fixed frequency band (valid symbol zone), It notes that a sending signal is not assigned to the subcarrier arranged out of a valid symbol zone, Even if the distortion by DC offset or a carrier leak arose in the subcarrier arranged out of this valid symbol zone, a bit error rate and transmission efficiency find out not deteriorating, and came to carry out this invention.
[0022]Namely, the main point of this invention so that the subcarrier to which the sending signal was assigned may be arranged in addition to a dc-component generating region, That is, it is preventing degradation of the bit error rate by DC offset and a carrier leak by carrying out the frequency modulation of the OFDM signal so that the subcarrier to which a sending signal was not assigned may be arranged to a dc-component generating region.
[0023]By the way, in the OFDM modulation method, in order to reduce the influence of the delayed wave by a multipass, the guard band is provided in the zone which adjoins a valid symbol zone. Since a sending signal is not assigned to the subcarrier contained in this guard band, even if the frequency position which intersects perpendicularly with the signal in an effective band in a guard band is overlapped on a line spectrum, a bit error rate does not deteriorate. On the other hand, in order to perform the recovery of an OFDM signal by sampling the signal of the certain area centering on DC, its sampling number at the time of getting over, so that the frequency modulation of the subcarrier to which the signal was assigned is carried out to a position far from DC increases. Therefore, in this invention, the sampling number in the case of a recovery can be reduced for the subcarrier to which the sending signal was assigned by the thing of a dc-component generating region immediately done for frequency modulation to an outside frequency band, and a processing burden can also be eased. This frequency modulation is realizable by carrying out frequency modulation so that the subcarrier contained in a guard band may be arranged to DC. That is, in this invention, the means which carries out the frequency modulation of the baseband signal so that the subcarrier arranged at the guard band may be arranged in a dc-component generating region is preferred.
[0024]In each following embodiment, the example which carries out the frequency modulation of the OFDM signal so that the subcarrier contained in a guard band may be arranged at DC is explained.
[0025](Embodiment 1) Embodiment 1 is an example which prevents degradation of the bit error rate by the DC offset and the carrier leak which are added in analog circuitry, such as an A/D converter of the transmitting side, and transmission efficiency.
[0026]Drawing 1 is a block diagram showing the composition of the OFDM sending set concerning the embodiment of the invention 1. Drawing 1 is an example of circuitry in the case of using five subcarriers for information transmission. In this figure, an OFDM sending set changes send data into a parallel signal with the S/P converter 101, IFFT (inverse discrete Fourier transform) processing is carried out with the IFFT machine 102, it changes into an in-series signal with the P/S converter 103, frequency modulation is carried out with the frequency modulator 104, D / A conversion is carried out with D/A converter 105, quadrature modulation is carried out with the quadrature modulation machine 106, and it transmits from the antenna 107. The frequency modulator 104 - the quadrature modulation machine 106 are explained in full detail behind. The IFFT

machine 102 arranges the subcarrier which does not assign a sending signal to the zone which adjoins the subcarrier which assigns a signal, and forms a guard band while it assigns a subcarrier peculiar to the sending signal to the parallel signal outputted from the S/P converter 101.

[0027]As a definition of term, send data is changed into a parallel signal with the S/P converter 101, IFFT (inverse discrete Fourier transform) processing is carried out with the IFFT machine 102, the processing changed into an in-series signal with the P/S converter 103 is summarized, and it is called Frequency-Division-Multiplexing processing. The signal to which frequency multiplexing split application was performed is called OFDM signal.

[0028]Drawing 2 is a block diagram showing the composition of the OFDM sending set of drawing 1, and the OFDM receiving set which performs radio. In this figure, an OFDM receiving set carries out orthogonal detection of the input signal received from the antenna 201 with the orthogonal detector 202, Analog-to-digital conversion is carried out with A/D converter 203, and it changes into a parallel signal with the S/P converter 204, and FFT (Fast Fourier Transform) processing is carried out with the FFT machine 205, and it changes into an in-series signal with the P/S converter 206, it gets over with the demodulator 207, and received data are obtained.

[0029]Next, operation of the OFDM sending set constituted as mentioned above and an OFDM receiving set is explained. Send data is changed into a parallel signal with the S/P converter 101, IFFT processing is carried out with the IFFT machine 102, and it is changed into an in-series signal with the P/S converter 103, and is outputted to the frequency modulator 104.

[0030]Here, the DC offset and the carrier leak ingredient which are added to an OFDM signal are explained. Drawing 3 is a figure showing the spectrum of an OFDM signal. Drawing 3 (a) is a spectrum of the OFDM signal inputted into the frequency modulator 104, Drawing 3 (b) is a spectrum of the OFDM signal with which DC offset was added in D/A converter 105, and the distortion (henceforth a "carrier leak ingredient") by a carrier leak was added in the quadrature modulation machine 106. In drawing 3 (a), the sending signal is assigned to the five subcarriers S1-S5, and these five subcarriers form a valid symbol zone. On the other hand, a sending signal is not assigned to the subcarriers S6 and S7, but a guard band for S6 and S7 to reduce distortion by a multipass is formed. That is, an OFDM signal comprises a guard band which adjoins a valid symbol zone and a valid symbol zone. By making 0 Hz (DC) into center frequency, 1 symbol length of a baseband signal leaves each subcarrier a reciprocal (=fs) every, and it is arranged.

[0031]Since each of DC offset and carrier leaks is generated in the 0-Hz neighborhood as a definition of term, DC offset and a carrier leak ingredient are collectively called dc component. The neighborhood of 0 Hz (DC) is called dc-component generating region in the meaning of the frequency domain which a dc component generates.

[0032]Frequency modulation is carried out in the frequency modulator 104, only 3 fs is shifted to the low frequency wave side, the signal shown in drawing 3 (a) is outputted to D/A converter 105, and D / A conversion is carried out in D/A converter 105. DC offset is added to the subcarrier arranged at DC in the case of this D / A conversion. This OFDM signal is outputted to the quadrature modulation machine 106, and the subcarrier of high frequency can multiply by it in the quadrature modulation machine 106. Distortion (carrier leak ingredient) occurs in the subcarrier arranged at DC of an OFDM

signal by inputting into the quadrature modulation machine 106 the subcarrier which leaked to space etc. Thus, the subcarrier S6 arranged at 3fs is arranged at DC until it is inputted into the frequency modulator 104, when only 3 fs is shifted an OFDM signal to the low frequency wave side in the frequency modulator 104. Therefore, DC offset and a carrier leak ingredient are added to the subcarrier S6 arranged at DC, and the spectrum of an OFDM signal comes to be shown in drawing 3 (b). In this case, the subcarriers S1-S5 to which the signal is assigned are arranged in addition to the dc-component generating region.

[0033]Quadrature modulation of the OFDM signal which has a spectrum shown in this drawing 3 (b) is carried out with the quadrature modulation machine 106, and it is transmitted from the antenna 107.

[0034]In an OFDM receiving set, the input signal received from the antenna 201, Orthogonal detection is carried out with the orthogonal detector 202, analog-to-digital conversion is carried out with A/D converter 203, and it is changed into a parallel signal with the S/P converter 204, and FFT processing is carried out with the FFT machine 205, and it is changed into an in-series signal with the P/S converter 206, it gets over with the demodulator 207, and received data are obtained. In this case, since the position of S6 which lies at right angles to S1-S5 is overlapped on the dc component and the FFT machine 205 can separate it thoroughly, it is uninfluential to S1-S5.

[0035]Thus, since according to this embodiment the subcarrier to which the signal was assigned by carrying out frequency modulation has been arranged in addition to a dc-component generating region before inputting an OFDM signal into the analog circuitry of an OFDM sending set, the subcarrier to which the signal was assigned is not distorted. Therefore, degradation of the bit error rate by DC offset and a carrier leak can be prevented.

[0036]According to this embodiment, since frequency modulation was carried out so that the subcarrier contained in a guard band might be arranged to a dc-component generating region, the sampling number in the case of a recovery can be stopped few.

[0037](Embodiment 2) Embodiment 2 is an example which prevents degradation of the bit error rate by the DC offset added in the analog circuitry of a receiver, and transmission efficiency.

[0038]Drawing 4 is a block diagram showing the composition of the OFDM sending set concerning the embodiment of the invention 2. Drawing 4 is an example of circuitry in the case of using five subcarriers for information transmission. In this figure, an OFDM sending set changes send data into a parallel signal with the S/P converter 401, IFFT (inverse discrete Fourier transform) processing is carried out with the IFFT machine 402, it changes into an in-series signal with the P/S converter 403, D / A conversion is carried out with D/A converter 404, the multiplication of the subcarrier is carried out by quadrature modulation with the quadrature modulation machine 405, and it transmits from the antenna 406. The IFFT machine 402 assigns a subcarrier to the parallel signal outputted from the S/P converter 401.

[0039]As a definition of term, send data is changed into a parallel signal with the S/P converter 401, IFFT (inverse discrete Fourier transform) processing is carried out with the IFFT machine 402, the processing changed into an in-series signal with the P/S converter 403 is summarized, and it is called Frequency-Division-Multiplexing processing.

[0040]Drawing 5 is a block diagram showing the composition of the OFDM sending set of drawing 4, and the OFDM receiving set which performs radio. On this figure and in the orthogonal detector 502 an OFDM receiving set, Orthogonal detection of the input signal (OFDM signal) received from the antenna 501 is carried out, Carry out frequency modulation with the frequency modulator 503, and analog-to-digital conversion is carried out with A/D converter 504, It changes into a parallel signal with the S/P converter 505, and FFT (Fast Fourier Transform) processing is carried out with the FFT machine 506, and it changes into an in-series signal with the P/S converter 507, it gets over with the demodulator 508, and received data are obtained.
[0041]Next, operation of the OFDM sending set constituted as mentioned above and an OFDM receiving set is explained. Send data is changed into a parallel signal with the S/P converter 401, and IFFT processing is carried out with the IFFT machine 402, It is changed into an in-series signal with the P/S converter 403, D / A conversion is carried out with D/A converter 404, quadrature modulation carries out the multiplication of the subcarrier with the quadrature modulation machine 405, and it is transmitted from the antenna 406.
[0042]In an OFDM receiving set, in the orthogonal detector 502, orthogonal detection of the input signal received from the antenna 501 is carried out, and it is outputted to the frequency modulator 503.
[0043]Here, the DC offset and the carrier leak ingredient which are added to an OFDM signal are explained. Drawing 6 is a figure showing the spectrum of an OFDM signal. Drawing 6 (a) is a spectrum of the OFDM signal inputted into the frequency modulator 503, and drawing 6 (b) is a spectrum of the OFDM signal with which DC offset was added in A/D converter 504. In drawing 6 (a), the sending signal is assigned to the five subcarriers S1-S5, and these five subcarriers form a valid symbol zone. On the other hand, a sending signal is not assigned to the subcarriers S6 and S7, but a guard band for S6 and S7 to reduce distortion by a multipass is formed. That is, an OFDM signal comprises a guard band which adjoins a valid symbol zone and a valid symbol zone. By making 0 Hz (DC) into center frequency, 1 symbol length of a baseband signal leaves each subcarrier a reciprocal (=fs) every, and it is arranged.
[0044]Frequency modulation is carried out in the frequency modulator 503, only 3 fs is shifted to the low frequency wave side, the signal shown in drawing 6 (a) is outputted to A/D converter 504, and analog-to-digital conversion is carried out in A/D converter 504. DC offset is added to the subcarrier arranged at DC in the case of this analog-to-digital conversion. Thus, the subcarrier S6 arranged at 3fs is arranged at DC until it is inputted into the frequency modulator 503, when only 3 fs is shifted an OFDM signal to the low frequency wave side in the frequency modulator 503. Therefore, DC offset is added to the subcarrier S6 arranged at DC, and the spectrum of an OFDM signal comes to be shown in drawing 6 (b). In this case, the subcarriers S1-S5 to which the signal is assigned are arranged in addition to the dc-component generating region.
[0045]The OFDM signal which has a spectrum shown in this drawing 6 (b) is changed into a parallel signal with the S/P converter 505, and FFT processing is carried out with the FFT machine 506, and it is changed into an in-series signal with the P/S converter 507, it gets over with the demodulator 508, and received data are obtained.
[0046]Thus, since according to this embodiment the subcarrier to which the signal was assigned by carrying out frequency modulation has been arranged in addition to a dc-

component generating region before inputting an OFDM signal into the analog circuitry of an OFDM receiving set, the subcarrier to which the signal was assigned is not distorted. Therefore, degradation of the bit error rate by DC offset and a carrier leak can be prevented.

[0047]It can use combining the OFDM sending set concerning the above-mentioned Embodiment 1, and the OFDM receiving set concerning Embodiment 2. Namely, the OFDM sending set concerning Embodiment 1 an OFDM signal, It transmits, after carrying out frequency modulation so that the subcarrier to which the signal was assigned may be arranged in addition to a dc-component generating region, After carrying out the frequency modulation of the OFDM signal received from the OFDM sending set which requires the OFDM receiving set concerning Embodiment 2 for Embodiment 1 so that the subcarrier assigned to the signal may be arranged in addition to a dc-component generating region, it inputs into analog circuitry and a recovery etc. are processed.

[0048]Thus, by using combining the OFDM sending set concerning Embodiment 1, and the OFDM receiving set concerning Embodiment 2, While being able to prevent degradation of the bit error rate by the DC offset and the carrier leak in the transmitting side, degradation of the bit error rate by the DC offset in a receiver can also be prevented.

[0049]Although the case where five subcarriers were contained in a valid symbol zone was explained, this invention is not restricted to this but it may be made to contain how many subcarriers in a valid symbol zone in each above-mentioned embodiment according to an equipment configuration. Although similarly the case where two subcarriers were included in a guard band was explained, it may be made for how many subcarriers to be included.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]The block diagram showing the composition of the OFDM sending set concerning the embodiment of the invention 1

[Drawing 2]The block diagram showing the composition of the OFDM sending set concerning the embodiment of the invention 1, and the OFDM receiving set which performs radio

[Drawing 3]The figure showing the spectrum of an OFDM signal

[Drawing 4]The block diagram showing the composition of the OFDM sending set concerning the embodiment of the invention 2

[Drawing 5]The block diagram showing the composition of the OFDM sending set concerning the embodiment of the invention 2, and the OFDM receiving set which performs radio

[Drawing 6]The figure showing the spectrum of an OFDM signal

[Description of Notations]

102, a 402 IFFT machine

104 and 503 Frequency modulator

105, 404 D/A converters

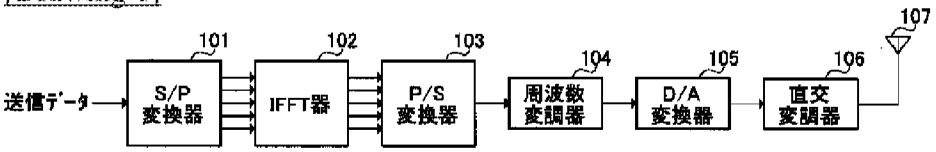
106 and 405 Quadrature modulation machine

203, 504 A/D converters

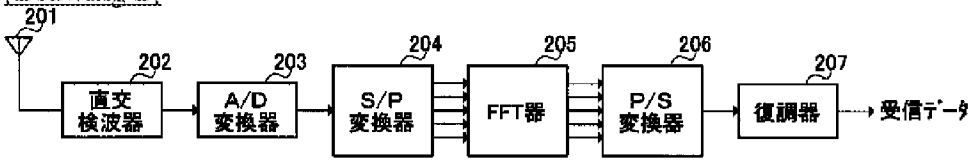
205, a 506 FFT machine
207 and 508 Demodulator

DRAWINGS

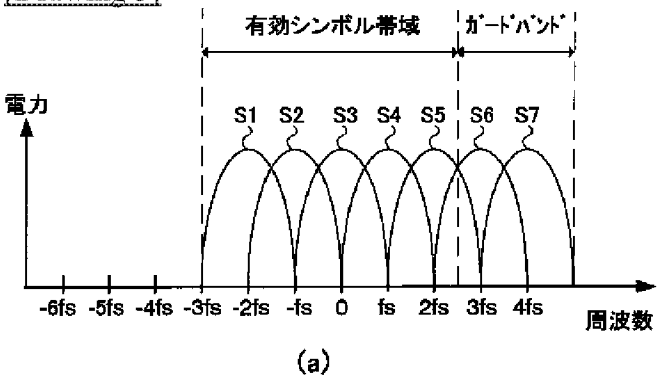
[Drawing 1]



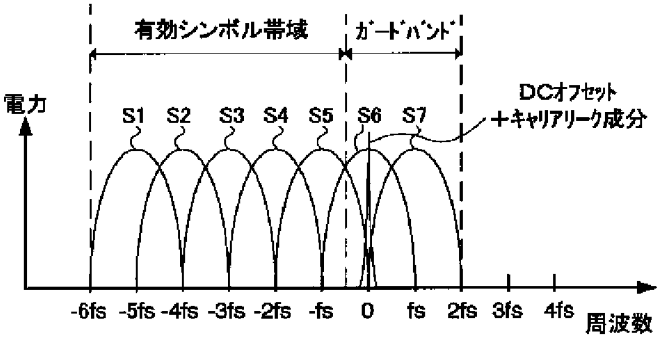
[Drawing 2]



[Drawing 3]

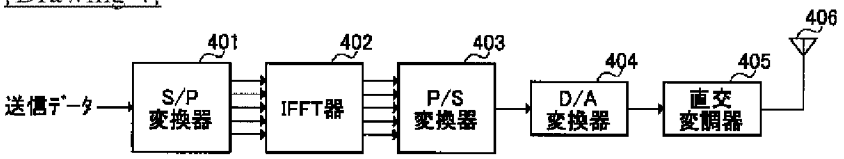


(a)

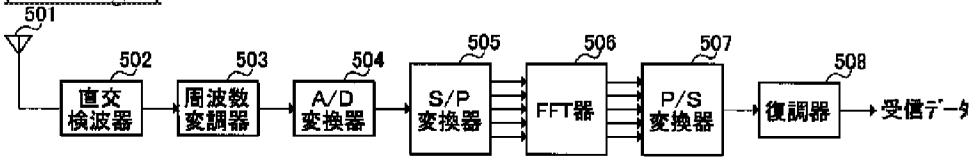


(b)

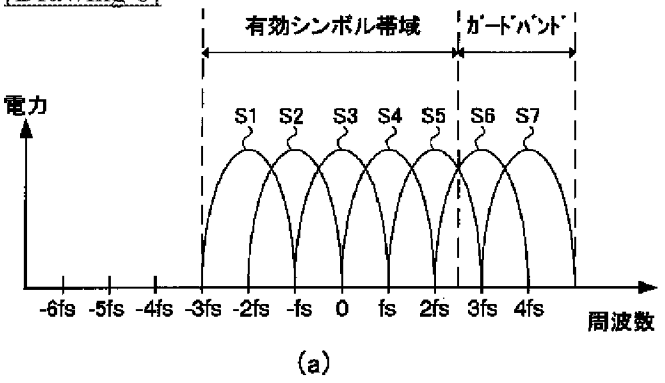
[Drawing 4]



[Drawing 5]



[Drawing 6]



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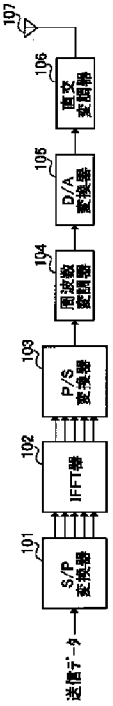
5K061 BB06 CC25

(54)【発明の名称】　ＯＦＤＭ送信装置及びＯＦＤＭ受信装置

(57)【要約】
【課題】　ＤＣオフセット及びキャリアリークによるビット誤り率の劣化及び信号の伝送効率の劣化を防止すること。
【解決手段】　送信データをＳ／Ｐ変換器１０１で並列信号に変換し、ＩＦＦＴ器１０２でＩＦＦＴ処理し、Ｐ／Ｓ変換器１０３で直列信号に変換し、周波数変調器１０４でＯＦＤＭ信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するようにＯＦＤＭ信号を周波数変調周波数変調する。



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【特許請求の範囲】

【請求項１】　送信信号を周波数分割多重処理することによりＯＦＤＭ信号を生成する生成手段と、前記ＯＦＤＭ信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するようにＯＦＤＭ信号を周波数変調する周波数変調手段と、を具備することを特徴とするＯＦＤＭ送信装置。

【請求項２】　周波数変調手段は、ＯＦＤＭ信号のガードバンドに含まれるサブキャリアのいずれか一つを直流成分発生領域に配置することを特徴とする請求項１に記載のＯＦＤＭ送信装置。

【請求項３】　周波数変調手段は、アナログ回路に入力する前にＯＦＤＭ信号を周波数変調することを特徴とする請求項１又は請求項２に記載のＯＦＤＭ送信装置。

【請求項４】　複数のサブキャリアが多重されたＯＦＤＭ信号を通信相手から受信する受信手段と、前記ＯＦＤＭ信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するようにＯＦＤＭ信号を周波数変調する周波数変調手段と、を具備することを特徴とするＯＦＤＭ受信装置。

【請求項５】　請求項１から請求項３のいずれかに記載のＯＦＤＭ送信装置から送信された信号を受信する受信手段と、前記受信手段が受信した受信信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するように前記受信信号を周波数変調する周波数変調手段と、を具備することを特徴とするＯＦＤＭ受信装置。

【請求項６】　送信信号を周波数分割多重処理することによりＯＦＤＭ信号を生成し、前記ＯＦＤＭ信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するようにＯＦＤＭ信号を周波数変調すること特徴とするＯＦＤＭ送信方法。

【請求項７】　送信側では、送信信号を周波数分割多重処理することによりＯＦＤＭ信号を生成し、前記ＯＦＤＭ信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するようにＯＦＤＭ信号を周波数変調して無線送信し、受信側では、送信側より送信された信号を受信し、受信信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するように前記受信信号を周波数変調することを特徴とする無線通信方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、ディジタル移動体通信システムに用いられる通信装置に関し、特に、ＯＦＤＭ（Orthogonal Frequency Division Multiplexing）方式を用いたＯＦＤＭ通信装置に関する。

【０００２】

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【従来の技術】伝送速度の高い無線通信を行う場合には、シンボル周期が短くなるのに伴い、マルチパス遅延波の影響が大きくなり受信信号品質は劣化する。このマルチパス遅延波による受信信号品質の劣化に対しては、マルチキャリア変調を行うことが有効である。マルチキャリア変調ではＩＦＦＴ（逆離散フーリエ変換：InverseFast Fourier Transform）回路を用いて複数の直交関係にあるサブキャリアを一括変調して多重するＯＦＤＭ変調方式が代表的である。

【０００３】ＯＦＤＭ変調方式では、ＤＣに配置されたサブキャリアに送信側のＤ／Ａ変換器等のアナログ回路で発生するＤＣオフセットが重畳されるので、伝送信号のビット誤り率が劣化するという問題がある。この問題は、受信側におけるＡ／Ｄ変換器等のアナログ回路においても同様に生じる。また、ベースバンド信号に乗算する高周波の搬送波が空間等に漏れるキャリアリークが発生し、この空間等に漏れた搬送波が直交変調器に入力されてＤＣに配置されたサブキャリアに歪みが生じることにより、伝送信号のビット誤り率が劣化するという問題もある。用語の定義として、ＯＦＤＭ変調方式におけるベースバンド信号の０Ｈｚの位置をＤＣという。

【０００４】これらの問題に対しては、例えば特開平１１－２０５１７６号公報で「マルチキャリア変調装置」が提案されている。上記特開平１１－２０５１７６号公報に記載の装置は、ＤＣにサブキャリアを配置しないことにより、アナログ回路におけるＤＣオフセット及びキャリアリークの影響を回避するものである。

【０００５】

【発明が解決しようとする課題】従来のＯＦＤＭ変調方式においては、ＤＣはベースバンド信号の周波数帯域の中央(０Ｈｚ)に位置するので、帯域制限による品質の劣化が最も少ない成分であり、最も伝送品質がよい。しかしながら、従来のＤＣにサブキャリアを配置しないＯＦＤＭ変調方式では、信号の伝送にＤＣを使用しないので、信号の伝送効率が低下するという問題がある。

【０００６】本発明はかかる点に鑑みてなされたものであり、ＤＣオフセット及びキャリアリークによるビット誤り率の劣化及び信号の伝送効率の劣化を防止するＯＦＤＭ送信装置及びＯＦＤＭ受信装置を提供することを目的とする。

【０００７】

【課題を解決するための手段】本発明のＯＦＤＭ送信装置は、送信信号を周波数分割多重処理することによりＯＦＤＭ信号を生成する生成手段と、前記ＯＦＤＭ信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するようにＯＦＤＭ信号を周波数変調する周波数変調手段と、を具備する構成を採る。

【０００８】この構成によれば、ＯＦＤＭ信号を周波数変調して、信号が割り当てられたサブキャリアを直流成

分発生領域以外に配置したので、信号が割り当てられたサブキャリアが歪まない。したがって、ＤＣオフセット及びキャリアリークによるビット誤り率の劣化を防ぐことができる。

【０００９】本発明のＯＦＤＭ送信装置は、上記ＯＦＤＭ送信装置において、周波数変調手段が、ＯＦＤＭ信号のガードバンドに含まれるサブキャリアのいずれか一つを直流成分発生領域に配置する構成を採る。

【００１０】この構成によれば、ＯＦＤＭ信号をアナログ回路に入力する前に周波数変調して、信号が割り当てられたサブキャリアを直流成分発生領域以外に配置したので、アナログ回路において発生するＤＣオフセット及びキャリアリークによっては信号が割り当てられたサブキャリアが歪まない。したがって、ＤＣオフセット及びキャリアリークによるビット誤り率の劣化を防ぐことができる。

【００１１】本発明のＯＦＤＭ送信装置は、上記ＯＦＤＭ送信装置において、周波数変調手段は、アナログ回路に入力する前にＯＦＤＭ信号を周波数変調する構成を採る。

【００１２】この構成によれば、ガードバンドに含まれるサブキャリアを直流成分発生領域に配置するように周波数変調したので、復調の際のサンプリング数を少なく抑えることができる。

【００１３】本発明のＯＦＤＭ受信装置は、複数のサブキャリアが多重されたＯＦＤＭ信号を通信相手から受信する受信手段と、前記ＯＦＤＭ信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するようにＯＦＤＭ信号を周波数変調する周波数変調手段と、を具備する構成を採る。

【００１４】この構成によれば、ＯＦＤＭ信号を周波数変調して、信号が割り当てられたサブキャリアを直流成分発生領域以外に配置したので、信号が割り当てられたサブキャリアが歪まない。したがって、樹脂側におけるＤＣオフセットによるビット誤り率の劣化を防ぐことができる。

【００１５】本発明のＯＦＤＭ受信装置は、上記ＯＦＤＭ送信装置から送信された信号を受信する受信手段と、前記受信手段が受信した受信信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するように前記受信信号を周波数変調する周波数変調手段と、を具備する構成を採る。

【００１６】この構成によれば、送信側におけるＤＣオフセット及びキャリアリークによるビット誤り率の劣化を防ぐことができるとともに、受信側におけるＤＣオフセットによるビット誤り率の劣化を防ぐこともできる。

【００１７】本発明のＯＦＤＭ送信方法は、送信信号を周波数分割多重処理することによりＯＦＤＭ信号を生成し、前記ＯＦＤＭ信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するようにＯＦＤＭ信号を周波数変調するようにした。

【００１８】この方法によれば、ＯＦＤＭ信号を周波数変調して、信号が割り当てられたサブキャリアを直流成分発生領域以外に配置したので、信号が割り当てられたサブキャリアが歪まない。したがって、ＤＣオフセット及びキャリアリークによるビット誤り率の劣化を防ぐことができる。

【００１９】本発明の無線通信方法は、送信側では、送信信号を周波数分割多重処理することによりＯＦＤＭ信号を生成し、前記ＯＦＤＭ信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するようにＯＦＤＭ信号を周波数変調して無線送信し、受信側では、送信側より送信された信号を受信し、受信信号を構成するサブキャリアのうち送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するように前記受信信号を周波数変調するようにした。

【００２０】この方法によれば、送信側におけるＤＣオフセット及びキャリアリークによるビット誤り率の劣化を防ぐことができるとともに、受信側におけるＤＣオフセットによるビット誤り率の劣化を防ぐこともできる。

【００２１】

【発明の実施の形態】本発明者は、周波数分割多重処理により生成されるＯＦＤＭ信号は一定の周波数帯域（有効シンボル帯域）を有しているため、有効シンボル帯域外に配置されたサブキャリアには送信信号が割り当てられないことに着目し、この有効シンボル帯域外に配置されたサブキャリアにＤＣオフセットやキャリアリークによる歪みが生じてもビット誤り率及び伝送効率は劣化しないことを見出して本発明をするに至った。

【００２２】すなわち、本発明の骨子は、送信信号が割り当てられたサブキャリアを直流成分発生領域以外に配置するように、すなわち、送信信号が割り当てられなかったサブキャリアを直流成分発生領域に配置するようにＯＦＤＭ信号を周波数変調することにより、ＤＣオフセット及びキャリアリークによるビット誤り率の劣化を防ぐことである。

【００２３】ところで、ＯＦＤＭ変調方式においては、マルチパスによる遅延波の影響を軽減するために有効シンボル帯域に隣接する帯域にガードバンドが設けられている。このガードバンドに含まれるサブキャリアには送信信号が割り当てられないため、ガードバンドの中で有効帯域内の信号と直交する周波数位置に線スペクトルが重畳されてもビット誤り率は劣化しない。一方、ＯＦＤＭ信号の復調はＤＣを中心とした一定領域の信号をサンプリングして行うため、信号が割り当てられたサブキャリアがＤＣから遠い位置に周波数変調されるほど復調する際のサンプリング数が増える。したがって本発明にお

いては、送信信号が割り当てられたサブキャリアを直流成分発生領域のすぐ外側の周波数帯域へ周波数変調することで、復調の際のサンプリング数を減らして処理負担を軽減することもできる。この周波数変調は、ガードバンドに含まれるサブキャリアをＤＣに配置するように周波数変調することにより実現することができる。すなわち、本発明においては、ガードバンドに配置されたサブキャリアが直流成分発生領域に配置されるようにベースバンド信号を周波数変調する手段が好適である。

【００２４】以下の各実施の形態においては、ガードバンドに含まれるサブキャリアがＤＣに配置されるようにＯＦＤＭ信号を周波数変調する例について説明する。

【００２５】（実施の形態１）実施の形態１は、送信側のＡ／Ｄ変換器等のアナログ回路で加わるＤＣオフセット及びキャリアリークによるビット誤り率及び伝送効率の劣化を防止する例である。

【００２６】図１は、本発明の実施の形態１に係るＯＦＤＭ送信装置の構成を示すブロック図である。図１は、情報伝送に５つのサブキャリアを用いる場合の回路構成例である。この図において、ＯＦＤＭ送信装置は、送信データをＳ／Ｐ変換器１０１で並列信号に変換し、ＩＦＦＴ器１０２でＩＦＦＴ（逆離散フーリエ変換）処理し、Ｐ／Ｓ変換器１０３で直列信号に変換し、周波数変調器１０４で周波数変調し、Ｄ／Ａ変換器１０５でディジタル・アナログ変換し、直交変調器１０６で直交変調し、アンテナ１０７から送信する。周波数変調器１０４～直交変調器１０６については後に詳述する。なお、ＩＦＦＴ器１０２は、Ｓ／Ｐ変換器１０１より出力された並列信号に対してその送信信号に固有のサブキャリアを割り当てるとともに、信号を割り当てるサブキャリアに隣接する帯域に送信信号を割り当てないサブキャリアを配置してガードバンドを形成する。

【００２７】用語の定義として、送信データをＳ／Ｐ変換器１０１で並列信号に変換し、ＩＦＦＴ器１０２でＩＦＦＴ（逆離散フーリエ変換）処理し、Ｐ／Ｓ変換器１０３で直列信号に変換する処理をまとめて周波数分割多重処理という。また、周波数多重分割処理を施された信号をＯＦＤＭ信号という。

【００２８】図２は、図１のＯＦＤＭ送信装置と無線通信を行うＯＦＤＭ受信装置の構成を示すブロック図である。この図において、ＯＦＤＭ受信装置は、アンテナ２０１から受信した受信信号を直交検波器２０２で直交検波し、Ａ／Ｄ変換器２０３でアナログ・ディジタル変換し、Ｓ／Ｐ変換器２０４で並列信号に変換し、ＦＦＴ器２０５でＦＦＴ（Fast Fourier Transform）処理し、Ｐ／Ｓ変換器２０６で直列信号に変換し、復調器２０７で復調して受信データを得る。

【００２９】次に、以上のように構成されたＯＦＤＭ送信装置及びＯＦＤＭ受信装置の動作について説明する。送信データは、Ｓ／Ｐ変換器１０１で並列信号に変換され、ＩＦＦＴ器１０２でＩＦＦＴ処理され、Ｐ／Ｓ変換器１０３で直列信号に変換されて周波数変調器１０４に出力される。

【００３０】ここで、ＯＦＤＭ信号に付加されるＤＣオフセット及びキャリアリーク成分について説明する。図３は、ＯＦＤＭ信号のスペクトルを表す図である。図３（ａ）は周波数変調器１０４に入力されるＯＦＤＭ信号のスペクトルであり、図３（ｂ）はＤ／Ａ変換器１０５においてＤＣオフセットが付加され、直交変調器１０６においてキャリアリークによる歪み（以下、「キャリアリーク成分」という）が付加されたＯＦＤＭ信号のスペクトルである。図３（ａ）において、送信信号は５つのサブキャリアＳ１～Ｓ５に割り当てられており、この５つのサブキャリアが有効シンボル帯域を形成する。一方、サブキャリアＳ６及びＳ７には送信信号が割り当てられず、Ｓ６及びＳ７がマルチパスによる歪みを軽減するためのガードバンドを形成する。すなわち、ＯＦＤＭ信号は、有効シンボル帯域及び有効シンボル帯域に隣接するガードバンドから構成される。各サブキャリアは０Ｈｚ（ＤＣ）を中心周波数として、ベースバンド信号の１シンボル長の逆数（＝ｆｓ）ずつ離れて配置されている。

【００３１】用語の定義として、ＤＣオフセット及びキャリアリークはいずれも０Ｈｚの近傍に発生するので、ＤＣオフセットとキャリアリーク成分とを併せて直流成分という。また、０Ｈｚ（ＤＣ）の近傍を直流成分が発生する周波数領域という意味で直流成分発生領域という。

【００３２】図３（ａ）に示す信号は、周波数変調器１０４において周波数変調されて３ｆｓだけ低周波側にシフトされてＤ／Ａ変換器１０５に出力され、Ｄ／Ａ変換器１０５においてディジタル・アナログ変換される。このディジタル・アナログ変換の際にＤＣに配置されたサブキャリアにＤＣオフセットが付加される。このＯＦＤＭ信号は直交変調器１０６に出力され、直交変調器１０６において高周波の搬送波が乗じられる。また、空間等に漏れた搬送波が直交変調器１０６に入力されることにより、ＯＦＤＭ信号のＤＣに配置されたサブキャリアに歪み（キャリアリーク成分）が発生する。このように、ＯＦＤＭ信号が周波数変調器１０４において３ｆｓだけ低周波側にシフトされた際に、周波数変調器１０４に入力されるまで３ｆｓに配置されていたサブキャリアＳ６がＤＣに配置される。したがって、ＤＣオフセットとキャリアリーク成分とがＤＣに配置されたサブキャリアＳ６に付加されて、ＯＦＤＭ信号のスペクトルは図３（ｂ）に示すようになる。この場合、信号が割り当てられているサブキャリアＳ１～Ｓ５は、直流成分発生領域以外に配置されている。

【００３３】この図３（ｂ）に示すスペクトルを有するＯＦＤＭ信号が直交変調器１０６で直交変調されてアン

テナ１０７から送信される。

【００３４】ＯＦＤＭ受信装置では、アンテナ２０１から受信した受信信号は、直交検波器２０２で直交検波され、Ａ／Ｄ変換器２０３でアナログ・ディジタル変換され、Ｓ／Ｐ変換器２０４で並列信号に変換され、ＦＦＴ器２０５でＦＦＴ処理され、Ｐ／Ｓ変換器２０６で直列信号に変換され、復調器２０７で復調されて受信データが得られる。この場合、直流成分はＳ１～Ｓ５と直交しているＳ６の位置に重畳されていて、ＦＦＴ器２０５によって完全に分離できるので、Ｓ１～Ｓ５に対して影響がない。

【００３５】このように、本実施の形態によれば、ＯＦＤＭ信号をＯＦＤＭ送信装置のアナログ回路に入力する前に周波数変調することにより、信号が割り当てられたサブキャリアを直流成分発生領域以外に配置したので、信号が割り当てられたサブキャリアが歪まない。したがって、ＤＣオフセット及びキャリアリークによるビット誤り率の劣化を防ぐことができる。

【００３６】本実施の形態では、ガードバンドに含まれるサブキャリアを直流成分発生領域に配置するように周波数変調したので、復調の際のサンプリング数を少なく抑えることができる。

【００３７】（実施の形態２）実施の形態２は、受信側のアナログ回路で加わるＤＣオフセットによるビット誤り率及び伝送効率の劣化を防止する例である。

【００３８】図４は、本発明の実施の形態２に係るＯＦＤＭ送信装置の構成を示すブロック図である。図４は、情報伝送に５つのサブキャリアを用いる場合の回路構成例である。この図において、ＯＦＤＭ送信装置は、送信データをＳ／Ｐ変換器４０１で並列信号に変換し、ＩＦＦＴ器４０２でＩＦＦＴ（逆離散フーリエ変換）処理し、Ｐ／Ｓ変換器４０３で直列信号に変換し、Ｄ／Ａ変換器４０４でディジタル・アナログ変換し、直交変調器４０５で直交変調により搬送波を乗算してアンテナ４０６から送信する。なお、ＩＦＦＴ器４０２は、Ｓ／Ｐ変換器４０１より出力された並列信号にサブキャリアを割り当てる。

【００３９】用語の定義として、送信データをＳ／Ｐ変換器４０１で並列信号に変換し、ＩＦＦＴ器４０２でＩＦＦＴ（逆離散フーリエ変換）処理し、Ｐ／Ｓ変換器４０３で直列信号に変換する処理をまとめて周波数分割多重処理という。

【００４０】図５は、図４のＯＦＤＭ送信装置と無線通信を行うＯＦＤＭ受信装置の構成を示すブロック図である。この図において、ＯＦＤＭ受信装置は、直交検波器５０２において、アンテナ５０１から受信した受信信号（ＯＦＤＭ信号）を直交検波し、周波数変調器５０３で周波数変調し、Ａ／Ｄ変換器５０４でアナログ・ディジタル変換し、Ｓ／Ｐ変換器５０５で並列信号に変換し、ＦＦＴ器５０６でＦＦＴ（Fast Fourier Transform）処理し、Ｐ／Ｓ変換器５０７で直列信号に変換し、復調器５０８で復調して受信データを得る。

【００４１】次に、以上のように構成されたＯＦＤＭ送信装置及びＯＦＤＭ受信装置の動作について説明する。送信データは、Ｓ／Ｐ変換器４０１で並列信号に変換され、ＩＦＦＴ器４０２でＩＦＦＴ処理され、Ｐ／Ｓ変換器４０３で直列信号に変換され、Ｄ／Ａ変換器４０４でディジタル・アナログ変換され、直交変調器４０５で直交変調により搬送波を乗算されてアンテナ４０６から送信される。

【００４２】ＯＦＤＭ受信装置では、アンテナ５０１から受信した受信信号は、直交検波器５０２において直交検波され、周波数変調器５０３に出力される。

【００４３】ここで、ＯＦＤＭ信号に付加されるＤＣオフセット及びキャリアリーク成分について説明する。図６は、ＯＦＤＭ信号のスペクトルを表す図である。図６（ａ）は周波数変調器５０３に入力されるＯＦＤＭ信号のスペクトルであり、図６（ｂ）はＡ／Ｄ変換器５０４においてＤＣオフセットが付加されたＯＦＤＭ信号のスペクトルである。図６（ａ）において、送信信号は５つのサブキャリアＳ１～Ｓ５に割り当てられており、この５つのサブキャリアが有効シンボル帯域を形成する。一方、サブキャリアＳ６及びＳ７には送信信号が割り当てられず、Ｓ６及びＳ７がマルチパスによる歪みを軽減するためのガードバンドを形成する。すなわち、ＯＦＤＭ信号は、有効シンボル帯域及び有効シンボル帯域に隣接するガードバンドから構成される。各サブキャリアは０Ｈｚ（ＤＣ）を中心周波数として、ベースバンド信号の１シンボル長の逆数（＝ｆｓ）ずつ離れて配置されている。

【００４４】図６（ａ）に示す信号は、周波数変調器５０３において周波数変調されて３ｆｓだけ低周波側にシフトされてＡ／Ｄ変換器５０４に出力され、Ａ／Ｄ変換器５０４においてアナログ・ディジタル変換される。このアナログ・ディジタル変換の際にＤＣに配置されたサブキャリアにＤＣオフセットが付加される。このように、ＯＦＤＭ信号が周波数変調器５０３において３ｆｓだけ低周波側にシフトされた際に、周波数変調器５０３に入力されるまで３ｆｓに配置されていたサブキャリアＳ６がＤＣに配置される。したがって、ＤＣオフセットがＤＣに配置されたサブキャリアＳ６に付加されて、ＯＦＤＭ信号のスペクトルは図６（ｂ）に示すようになる。この場合、信号が割り当てられているサブキャリアＳ１～Ｓ５は、直流成分発生領域以外に配置されている。

【００４５】この図６（ｂ）に示すスペクトルを有するＯＦＤＭ信号は、Ｓ／Ｐ変換器５０５で並列信号に変換され、ＦＦＴ器５０６でＦＦＴ処理され、Ｐ／Ｓ変換器５０７で直列信号に変換され、復調器５０８で復調されて受信データが得られる。

【００４６】このように、本実施の形態によれば、ＯＦＤＭ信号をＯＦＤＭ受信装置のアナログ回路に入力する前に周波数変調することにより、信号が割り当てられたサブキャリアを直流成分発生領域以外に配置したので、信号が割り当てられたサブキャリアが歪まない。したがって、ＤＣオフセット及びキャリアリークによるビット誤り率の劣化を防ぐことができる。

【００４７】なお、上記実施の形態１に係るＯＦＤＭ送信装置と実施の形態２に係るＯＦＤＭ受信装置とを組み合わせて用いることができる。すなわち、実施の形態１に係るＯＦＤＭ送信装置がＯＦＤＭ信号を、信号が割り当てられたサブキャリアが直流成分発生領域以外に配置されるように周波数変調してから送信し、実施の形態２に係るＯＦＤＭ受信装置が実施の形態１に係るＯＦＤＭ送信装置から受信したＯＦＤＭ信号を、信号が割り当てられたサブキャリアが直流成分発生領域以外に配置されるように周波数変調してからアナログ回路に入力して復調等の処理を行う。

【００４８】このように、実施の形態１に係るＯＦＤＭ送信装置と実施の形態２に係るＯＦＤＭ受信装置とを組み合わせて用いることにより、送信側におけるＤＣオフセット及びキャリアリークによるビット誤り率の劣化を防ぐことができるとともに、受信側におけるＤＣオフセットによるビット誤り率の劣化を防ぐこともできる。

【００４９】なお、上記各実施の形態においては、有効シンボル帯域に５つのサブキャリアが含まれる場合について説明したが、本発明はこれに限られず、装置構成に応じて有効シンボル帯域にいくつのサブキャリアを含むようにしても良い。同様に、ガードバンドに２つのサブキャリアを含む場合について説明したが、いくつのサブキャリアを含むようにしても良い。

【００５０】

【発明の効果】以上説明したように、本発明によれば、ＤＣオフセット及びキャリアリークによるビット誤り率の劣化及び信号の伝送効率の劣化を防止することができる。

【図面の簡単な説明】

【図１】本発明の実施の形態１に係るＯＦＤＭ送信装置の構成を示すブロック図

【図２】本発明の実施の形態１に係るＯＦＤＭ送信装置と無線通信を行うＯＦＤＭ受信装置の構成を示すブロック図

【図３】ＯＦＤＭ信号のスペクトルを表す図

【図４】本発明の実施の形態２に係るＯＦＤＭ送信装置の構成を示すブロック図

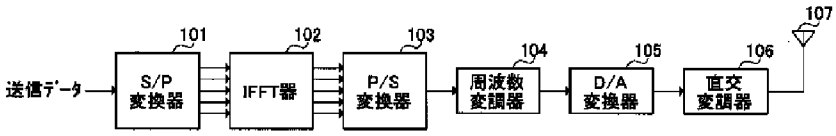
【図５】本発明の実施の形態２に係るＯＦＤＭ送信装置と無線通信を行うＯＦＤＭ受信装置の構成を示すブロック図

【図６】ＯＦＤＭ信号のスペクトルを表す図

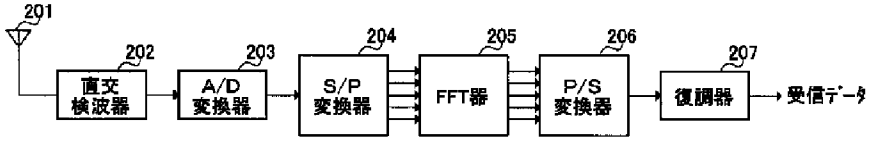
【符号の説明】

１０２、４０２　ＩＦＦＴ器
１０４、５０３　周波数変調器
１０５、４０４　Ｄ／Ａ変換器
１０６、４０５　直交変調器
２０３、５０４　Ａ／Ｄ変換器
２０５、５０６　ＦＦＴ器
２０７、５０８　復調器

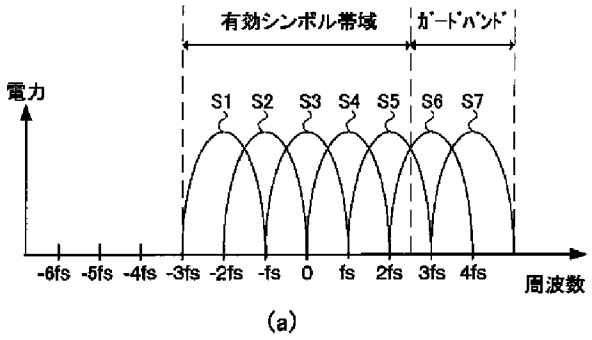
【図１】



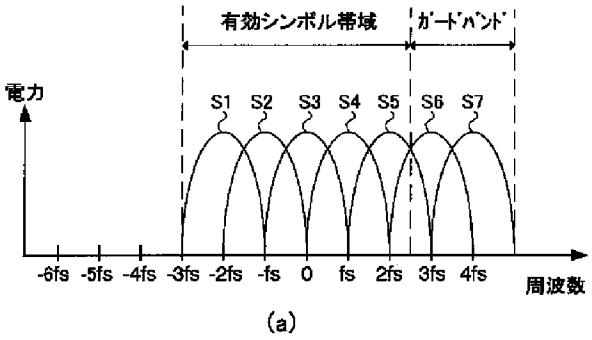
【図２】



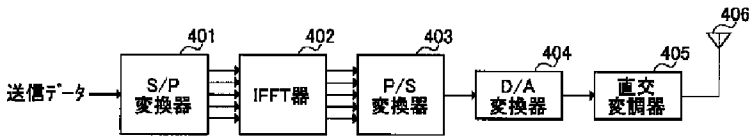
【図３】


有効シンボル帯域
ｶﾞｰﾄﾞﾊﾞﾝﾄﾞ
電力
S1 S2 S3 S4 S5 S6 S7
-6fs -5fs -4fs -3fs -2fs -fs 0 fs 2fs 3fs 4fs
周波数
(a)
有効シンボル帯域
ｶﾞｰﾄﾞﾊﾞﾝﾄﾞ
電力
S1 S2 S3 S4 S5 S6 S7
DCオフセット
＋キャリアリーク成分
-6fs -5fs -4fs -3fs -2fs -fs 0 fs 2fs 3fs 4fs
周波数
(b)

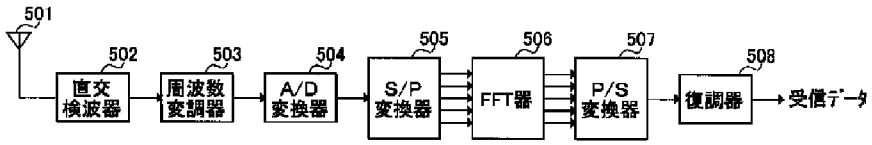
【図６】


有効シンボル帯域
ｶﾞｰﾄﾞﾊﾞﾝﾄﾞ
電力
S1 S2 S3 S4 S5 S6 S7
-6fs -5fs -4fs -3fs -2fs -fs 0 fs 2fs 3fs 4fs
周波数
(a)
有効シンボル帯域
ｶﾞｰﾄﾞﾊﾞﾝﾄﾞ
電力
S1 S2 S3 S4 S5 S6 S7
DCオフセット
-6fs -5fs -4fs -3fs -2fs -fs 0 fs 2fs 3fs 4fs
周波数
(b)

【図４】


送信ﾃﾞｰﾀ
S/P 変換器
401
IFFT器
402
P/S 変換器
403
D/A 変換器
404
直交 変調器
405
406

【図５】


501
直交 検波器
502
周波数 変調器
503
A/D 変換器
504
S/P 変換器
505
FFT器
506
P/S 変換器
507
復調器
508
受信ﾃﾞｰﾀ